A characterisation of silicon pixel sensors for the Inner Tracker (ITk), an upgrade of the ATLAS inner detector foreseen for the HL-LHC, is performed. It consists of visual and electrical tests using a probe station, as well as sensor efficiency studies at the DESY test beam facility. The measurements are evaluated in the scope of a market survey which aims to qualify commercial vendors for the production of the pixel sensors of the ITk. Based on these results a decision will be made in 2020 as to which vendors will enter the tender.

The ATLAS ITk Detector

ATLAS at the HL-LHC:
- HL-LHC expected to begin operations = 2027
- Instantaneous (integrated) Luminosity increased by factor of $\geq 3.5 (= 10)$
  ⇒ Requirement for radiation-hard detectors and fast readout

The ITk: An all-silicon tracker:
- ATLAS Inner Detector will be replaced by Inner Tracker (ITk)
- ITk consists of silicon strip (outside) and pixel sensors (inside)
- One layer of 3D pixel sensors surrounded by layers of planar sensors
- Planar thickness: 100 µm in layer 1 and 150 µm in layers 2-4
- Planar pixel size: 50 × 50 µm$^2$ (also tested: 25 × 100 µm$^2$)

Visual Inspection:
- Manual scan with microscope on each sensor to identify possible defects
- Find missing or deformed bump-pads

Visual and Geometrical Inspection
- Visual inspection
- Thickness and planarity
- Depletion voltage
- Leakage current
- Leakage current per area
- Leakage current stability
- Breakdown voltage
- Hit efficiency in beam tests
- Source scans

Market Survey
- Non-irradiated sensors from one of the 6 foundries have been tested:
  - Measurements on sensors with punch through biasing structures
  - Laser scan of planar thickness to achieve most uniform biasing
  - Planar pixel size 50 × 50 µm$^2$

Requirements and Analysis:
- Before irrad.: 98.5 % efficiency at $V_{\text{bias}} = +50$ V
- After irrad.: 97.0 % efficiency at $V_{\text{bias}} = +50$ V for 100 µm, 150 µm thick sensors
- Location of punch through bias dots visible as inefficiencies (expected to be less pronounced at incidence $\neq 90^\circ$)